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Isenhour et al.

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(54) **FIBER OPTIC PLUG ASSEMBLY AND OPTICAL CONNECTOR SYSTEM**

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(51) **Int. Cl.**
G02B 6/38 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/3807*** (2013.01); ***G02B 6/3847*** (2013.01); ***G02B 6/3853*** (2013.01); ***G02B 6/3885*** (2013.01); ***G02B 6/3893*** (2013.01); *G02B 6/3821* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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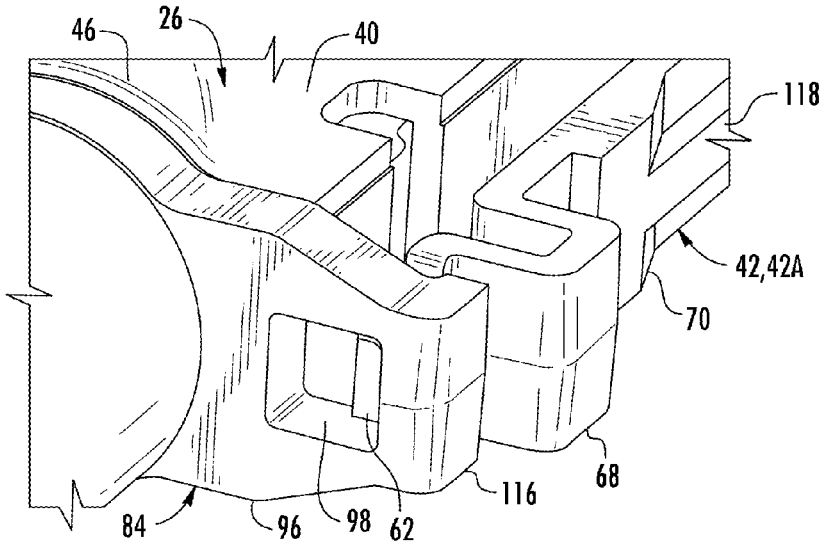
(57) **ABSTRACT**

A fiber optic plug assembly for a fiber optic cable includes a plug body and cable attachment element. The plug body has a main portion with a front end and back end and at least one latching arm extending from the main portion. The cable attachment element has a front portion received in the back end of the main portion of the plug body, a rear portion located outside of the plug body, and a passage configured to allow at least one optical fiber to extend through the cable attachment element and into the main portion of the plug body. The rear portion of the cable attachment element receives at least a portion of the at least one latching arm. An optical connector system with a fiber optic plug assembly is also provided.

16 Claims, 5 Drawing Sheets



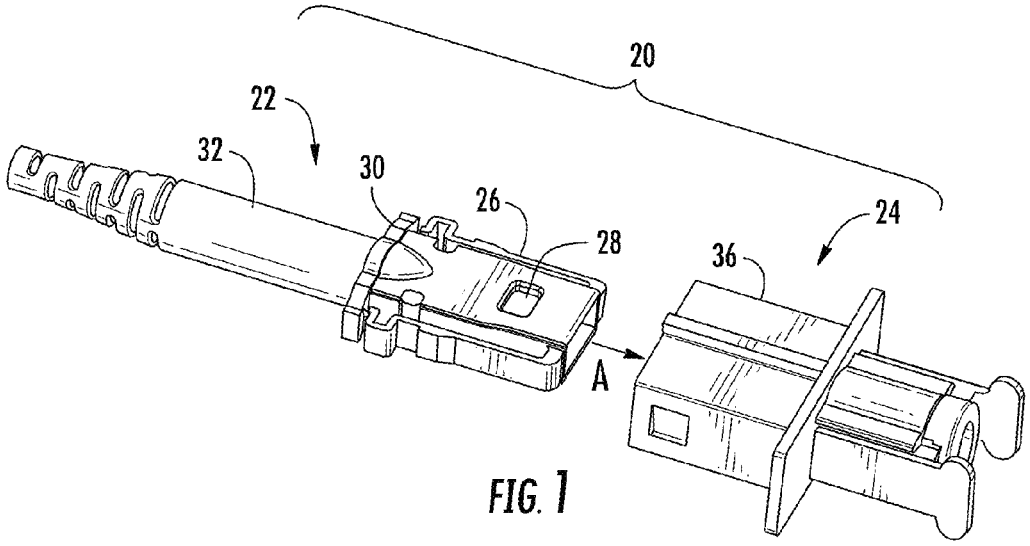


FIG. 1

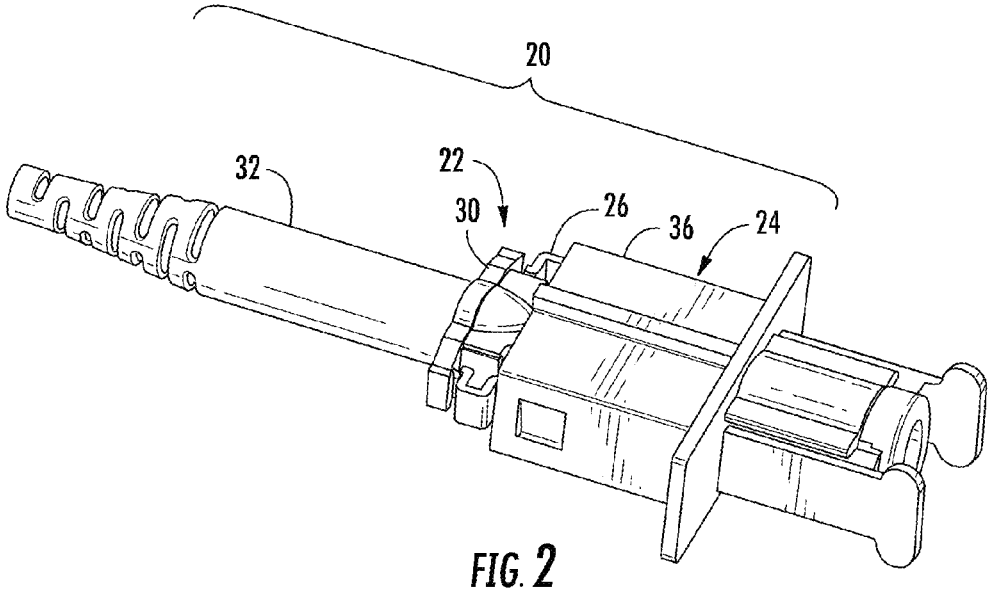


FIG. 2

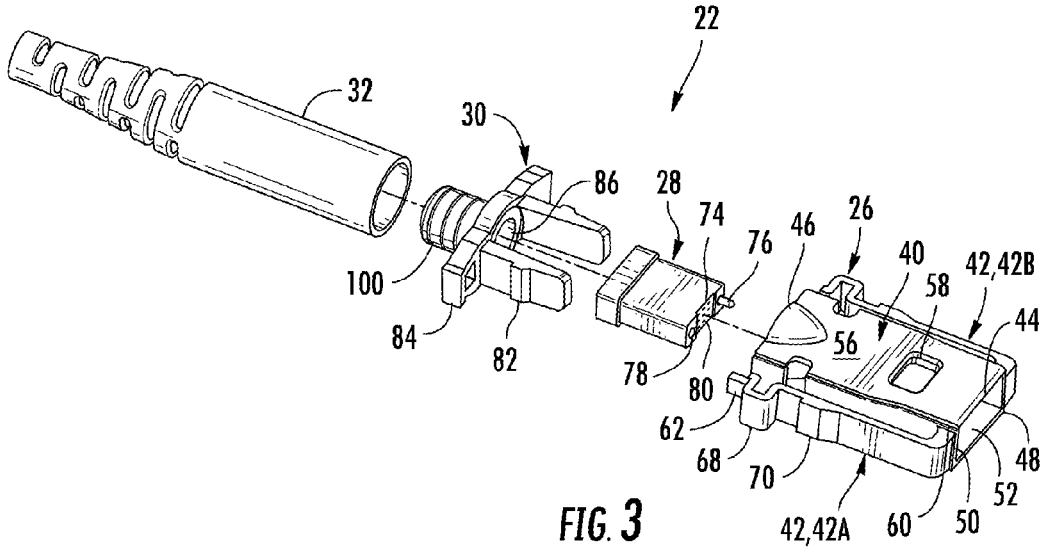

22
32
30
86
28
74
76
46
26
40
42,42B
58
44
100
84
82
78
80
56
62
68
70
48
52
42,42A
60
50

FIG. 3

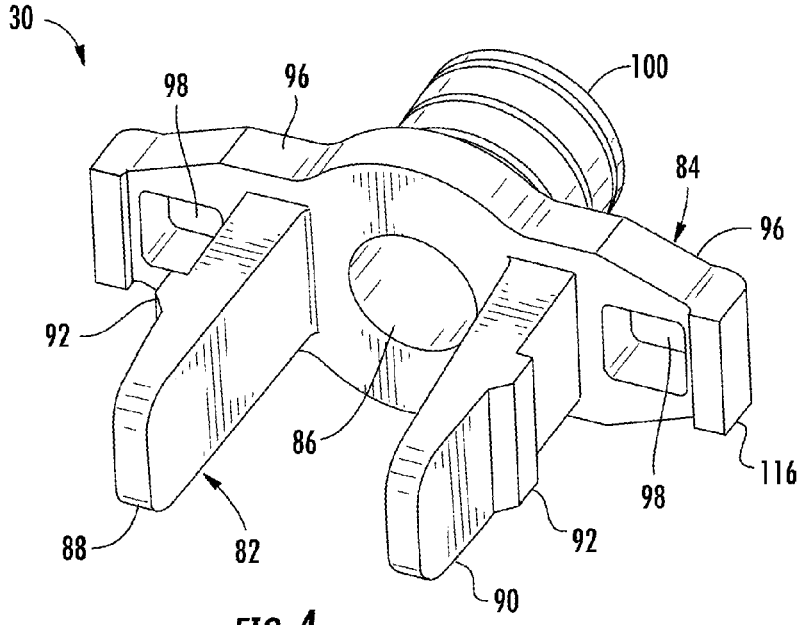

30
98
96
100
84
96
92
86
116
98
88
82
92
90

FIG. 4

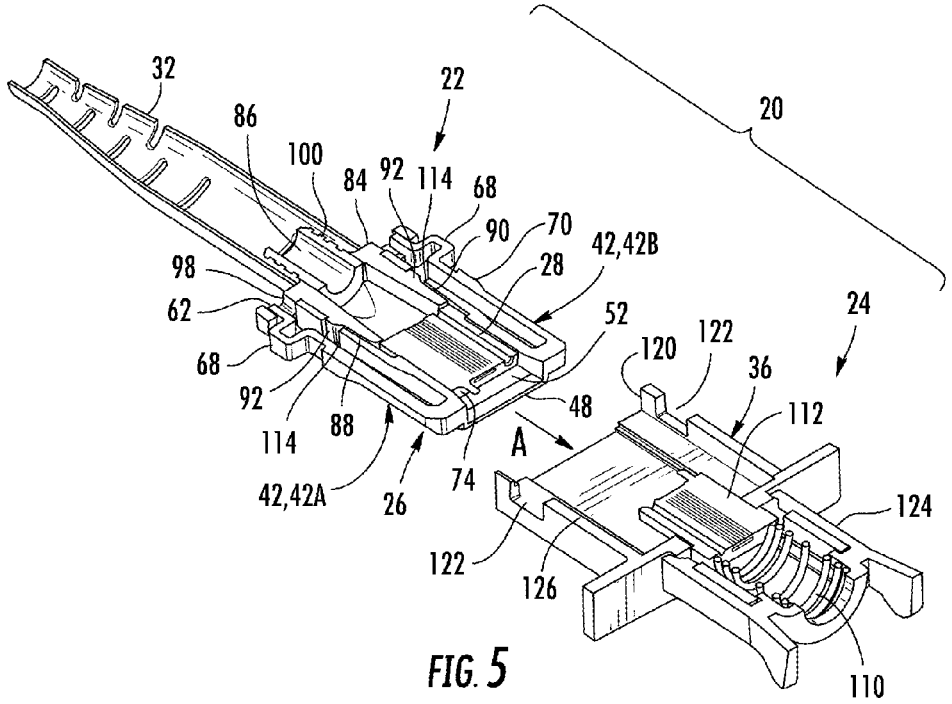
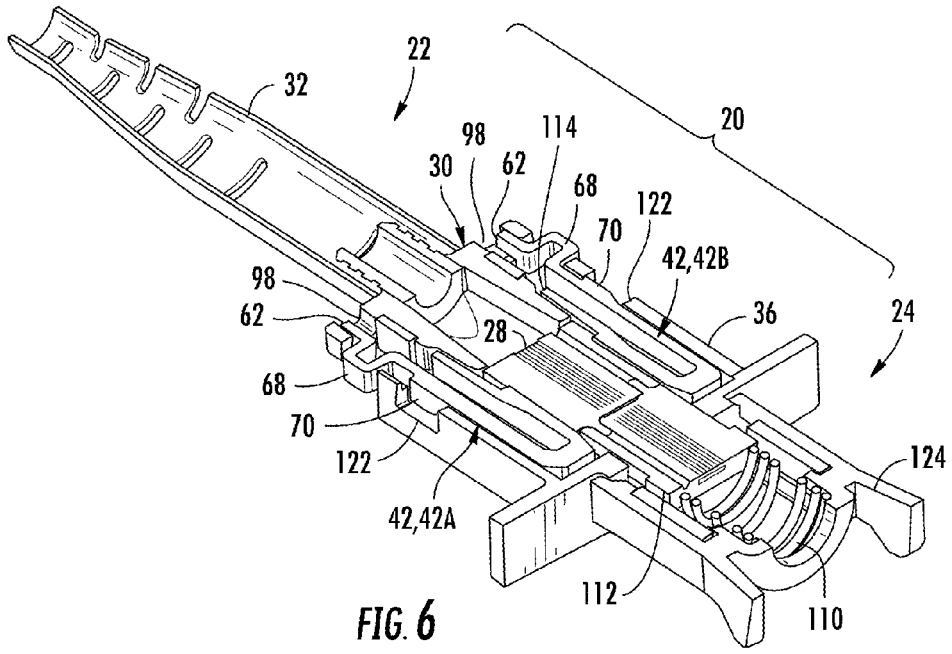

32
86
22
20
100
84
92
114
68
90
70
42,42B
28
98
62
52
24
120
122
68
36
92
112
48
114
88
A
42,42A
26
74
124
122
126
110

FIG. 5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32
20
98
114
30
62
68
122
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42,42B
98
62
36
24
28
68
70
122
124
42,42A
112
110

FIG. 6

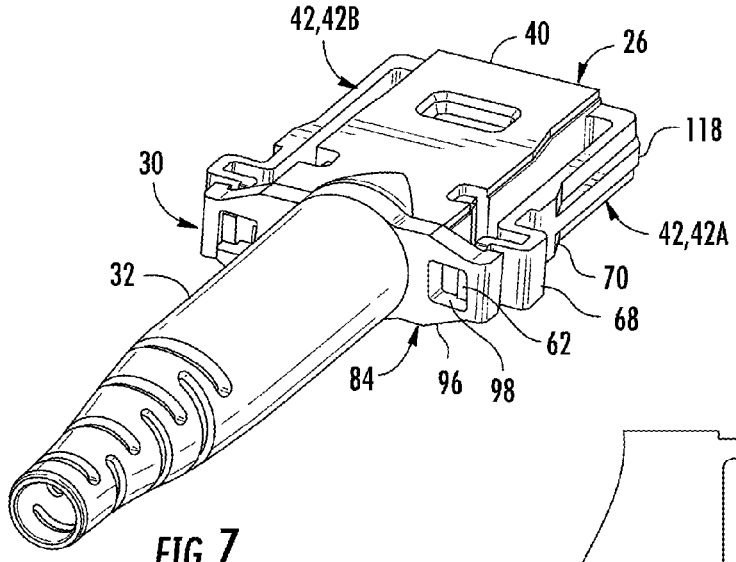


FIG. 7

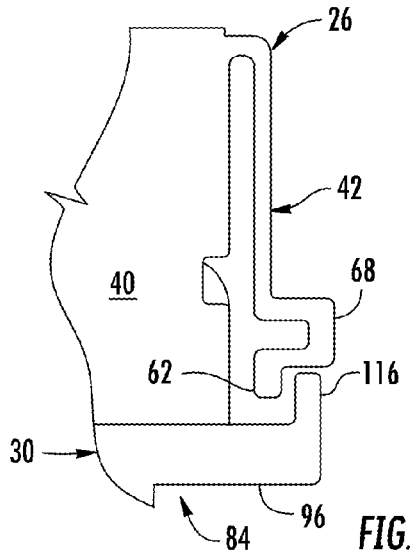


FIG. 8A

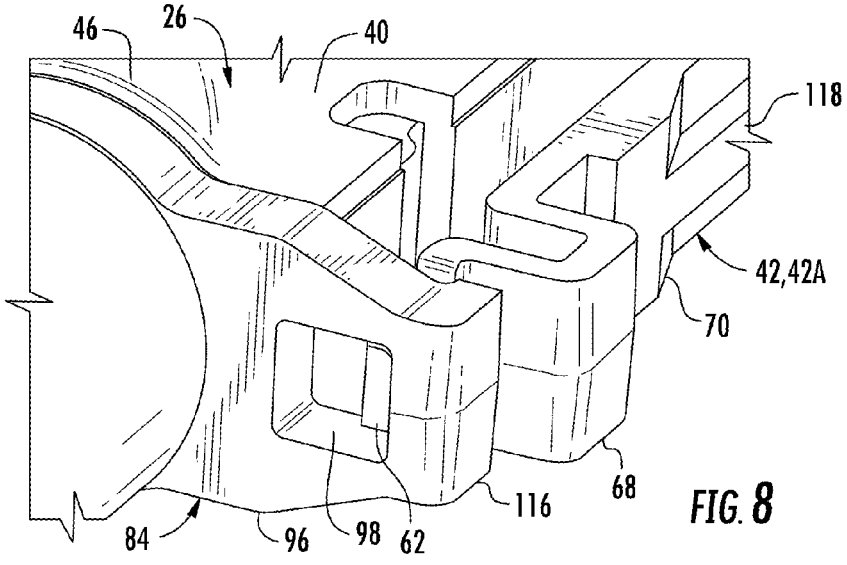
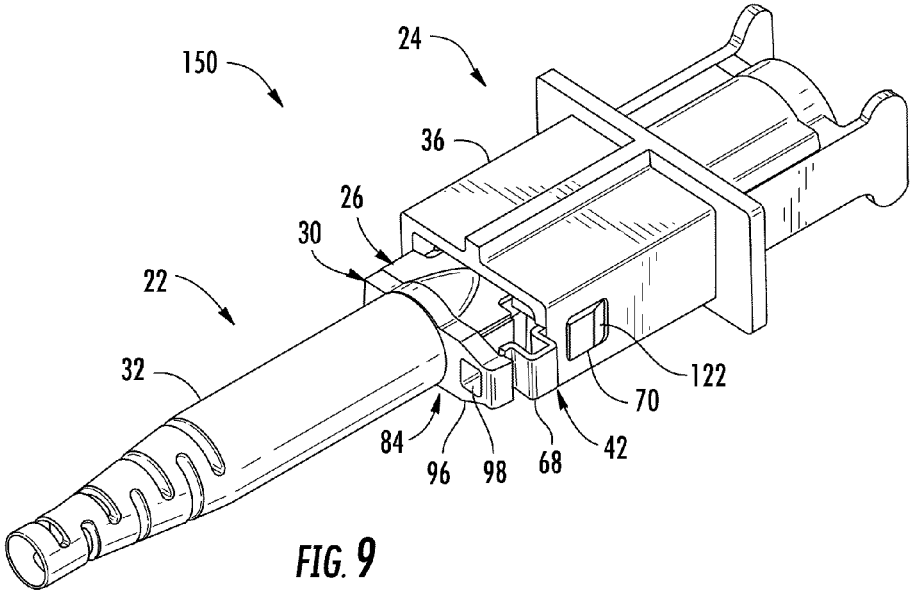


FIG. 8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24
36
26
30
22
32
122
70
84
96
98
68
42

FIG. 9

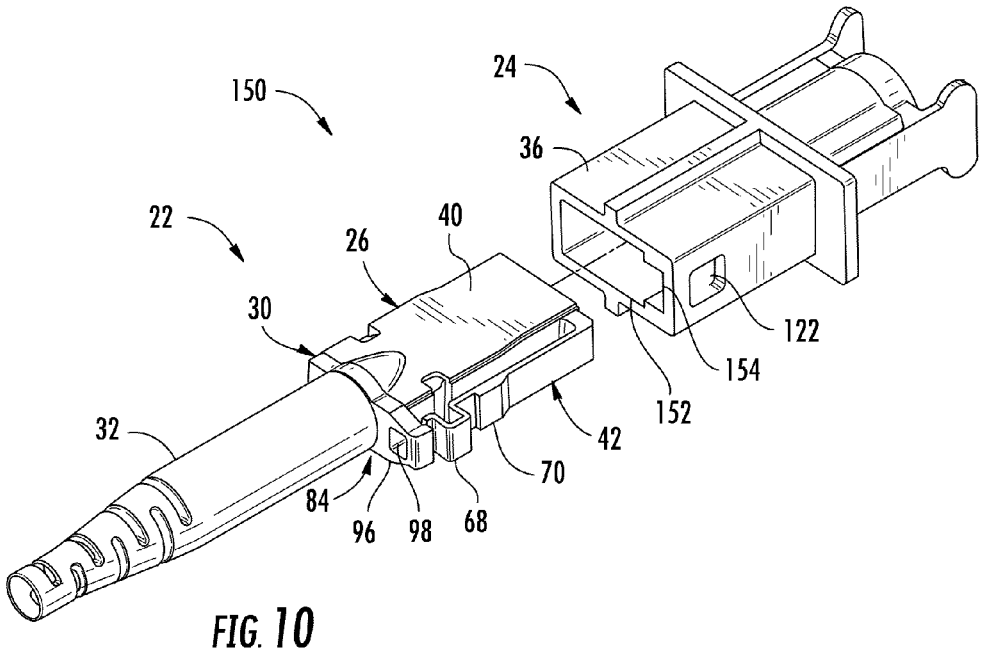
150
24
36
22
40
26
30
122
154
152
32
42
70
84
96
98
68

FIG. 10

FIBER OPTIC PLUG ASSEMBLY AND OPTICAL CONNECTOR SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority under 35 U.S.C. §119 of U.S. Provisional Application Ser. No. 61/731,581 filed on Nov. 30, 2012, the content of which is relied upon and incorporated herein by reference in its entirety.

FIELD

The disclosure relates to generally to fiber optic connectors, and more particularly to fiber optic plug assemblies and optical connector systems including the same.

BACKGROUND

Fiber optic cables include one or more optical fibers that transmit signals in the form of light. The optical fibers provide extremely wide bandwidth, low noise operation, and other well-known benefits.

In a system that uses fiber optic cables, there are typically several locations where the fiber optic cables connect to equipment or other fiber optic cables. The transfer of light at these locations is typically accomplished by optical connector systems that mate one component with another. At least one of the mating components in an optical connector system is often referred to as a "fiber optic connector" (or simply "connector"). For example, connectors are often used in cable management systems to provide service connections to rack-mounted equipment and to provide inter-rack connections.

Many different types of connectors have been developed. As one example of a connector, a MPO-style connector is a multi-fiber connector suitable for high-density backplane and printed circuit board (PCB) applications in data and telecom systems. MPO-style connectors generally utilize adapters, which align the MPO-style connectors with other multi-fiber connectors for forming a connection therebetween.

Connectors are typically designed to not only mate, but also unmate with another component. In other words, the connection is not necessarily intended to be permanent. The parts of a connector may therefore require handling and be exposed to the surrounding environment, including other nearby structures, at some point during the life of the connector. Ensuring that the parts of the connector do not become damaged can be a challenge.

SUMMARY

Embodiments of a fiber optic plug assembly for a fiber optic cable are disclosed herein. The fiber optic plug assembly may be part of an optical connector system, embodiments of which are also disclosed.

According to one embodiment, the fiber optic plug assembly includes a plug body and cable attachment element. The plug body has a main portion with a front end and back end and at least one latching arm extending from the main portion. The cable attachment element has a front portion received in the back end of the main portion of the plug body, a rear portion located outside of the plug body, and a passage configured to allow at least one optical fiber to extend through the cable attachment element and into the main portion of the plug body. The rear portion of the cable attachment element receives at least a portion of the at least one latching arm.

According to another embodiment, the rear portion of the cable attachment element that receives the at least one latching arm comprises a receiving zone that at least partially surrounds a portion of the at least one latching arm. And in a further embodiment, the at least one latching arm has a proximal end attached to the main portion of the plug body and a distal end offset from the main portion. The receiving zone on the rear portion of the cable attachment element at least partially surrounds the distal end of the at least one latching arm. In still further embodiments, the receiving zone on the rear portion of the cable attachment element comprises an opening in which the distal end of the at least one latching arm is positioned. The opening of the receiving zone may extend through the rear portion of the cable attachment element such that the distal end of the at least one latching arm may extend partially or completely through the receiving zone.

According to another embodiment, the plug body further defines a plug body opening at the front end of the main portion and a ferrule enclosure coupled in free space to the plug body opening. A plug ferrule element is disposed within the ferrule enclosure of the plug body and accessible through the plug body opening.

According to yet another embodiment, a fiber optic plug assembly includes a plug body having main portion and at least one latching arm extending from the main portion. The latching arm is movable toward and away from the main portion. The fiber optic plug assembly also includes a cable attachment element coupled to the main portion of the plug body. A portion of the cable attachment element is configured to restrict movement of the latching arm away from the main portion of the plug body. This portion of the cable attachment element may include a flange extending away from the main portion of the plug body and a receiving zone provided on the flange. The receiving zone may include a terminal portion of the flange that extends next to the latching arm on a side of the latching arm opposite the main portion of the plug body. Alternatively or additionally, the receiving zone may at least partially surround a portion of the at least one latching arm.

One embodiment of an optical connector system includes a fiber optic plug assembly according to one of the embodiments above and a fiber optic receptacle assembly for mating with the fiber optic plug assembly. The fiber optic receptacle assembly has a receptacle housing that defines a receptacle enclosure configured to receive the plug body of the fiber optic plug assembly. Additionally, the receptacle housing includes at least one locking mechanism configured to engage the at least one latching arm of the plug body when the plug body is inserted into the receptacle enclosure.

The fiber optic plug assemblies according to the present disclosure have a safe and robust design. With the rear portion of the cable attachment element surrounding at least a portion of the one or more latching arms, the latching arm(s) may be less prone to catching or snagging nearby structures when being handled. Therefore, the latching arm(s) may be less prone to unwanted deformations or breakage. Furthermore, the safe and robust design may be achieved without significantly increasing the complexity of the optical connector system. The advantageous features are conveniently integrated into parts of the fiber optic plug assembly that serve other purposes. This may also be done in a manner that does not significantly increase the overall size of the fiber optic plug assembly or otherwise interfere with the esthetic and/or ergonomic characteristics of the fiber optic plug assembly.

Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments as described

herein, including the detailed description which follows, the claims, as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description are merely exemplary, and are intended to provide an overview or framework to understanding the nature and character of the claims. The accompanying drawings are included to provide a further understanding, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s), and together with the description serve to explain principles and operation of the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the objects, advantages, and principles of the invention. In the drawings:

FIG. **1** is a perspective view an optical connector system according to one embodiment including an exemplary fiber optic plug assembly and exemplary fiber optic receptacle assembly in a disconnected state;

FIG. **2** is a perspective view of the optical connector system shown in FIG. **1** with the fiber optic plug assembly and fiber optic receptacle assembly in a connected state;

FIG. **3** is an exploded perspective view of the fiber optic plug assembly shown in FIGS. **1** and **2**;

FIG. **4** is a perspective view of a cable attachment element that is part of the fiber optic plug assembly shown in FIGS. **1-3**;

FIG. **5** is a cross-sectional perspective view of the optical connector system shown in FIGS. **1** and **2** with the fiber optic plug assembly and the fiber optic receptacle assembly in a disconnected state;

FIG. **6** is a cross-sectional perspective view of the optical connector system shown in FIGS. **1** and **2** with the fiber optic plug assembly and the fiber optic receptacle assembly in a connected state;

FIG. **7** is a perspective view of the fiber optic plug assembly shown in the preceding figures wherein the fiber optic plug assembly is shown in isolation and from a different angle;

FIG. **8** is an enlarged perspective view of a portion of the fiber optic plug assembly shown in FIG. **7** depicting an exemplary latching arm and receiving zone;

FIG. **8**A is a schematic view of a portion of a fiber optic plug assembly according to an alternative embodiment;

FIG. **9** is a perspective view of an alternative embodiment of an optical connector system including an exemplary a fiber optic plug assembly and an exemplary fiber optic receptacle assembly in a connected state; and

FIG. **10** is a perspective view of the optical connector system shown in FIG. **9** wherein the fiber optic plug assembly and the fiber optic receptacle assembly are in a disconnected state.

DETAILED DESCRIPTION

Reference will now be made in detail to optical connector systems having fiber optic plug assemblies, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

The optical connector systems described herein facilitate the exchange of information over optical fibers. Ends of the optical fibers may be coupled to ends of other optical fibers or to another optical element by the optical connector systems. This may occur at various locations along the path over which the information is sent. The optical connector systems described herein may be, for example, optical data center connector systems. Such optical connector systems typically provide information pathways within data center equipment like racks and cabinets. However, the disclosure is not limited to such applications; other embodiments and applications besides data centers are possible. Furthermore, although the optical connector systems described herein establish the information pathways by mating plug ferrule elements within the fiber optic plug assemblies to receptacle ferrule elements within fiber optic receptacle assemblies, embodiments will be appreciated where the optical connector systems do not use ferrule elements or only use ferrule elements in one of the mating components.

With this mind, FIGS. **1** and **2** illustrate an exemplary embodiment of an optical connector system **20** in disconnected and connected states, respectively. The optical connector system **20** includes a fiber optic plug assembly **22** and fiber optic receptacle assembly **24**. As will be described in greater detail below, the fiber optic plug assembly **22** includes particular features for improving robustness and facilitating use. First, however, a general description of the assemblies and their connection to each other will be provided.

In general, and with additional reference to FIG. **3**, the fiber optic plug assembly **22** includes a plug body **26**, plug ferrule element **28**, cable attachment element **30**, and optional strain relief element **32**. The plug body **26** houses the plug ferrule element **28** and is used to secure the fiber optic plug assembly **22** to the fiber optic receptacle assembly **24**. The plug ferrule element **28** is provides an optical interface and thereby allow the transmission of optical signals to a mating component. Persons skilled in the art will appreciate that the optical signals may be delivered by an optical waveguide in a fiber optic cable (not shown) coupled to the fiber optic plug assembly **22**. The fiber optic cable may include one or more optical fibers carried within an outer jacket, for example. The cable attachment element **30** is configured to secure the fiber optic plug assembly **22** to the fiber optic cable and allow the optical fibers to extend to the plug ferrule element **28**. The strain relief element **32** may also be provided to relieve bending stress and shield or cover the connection between the cable attachment element **30** and fiber optic cable.

Referring to FIGS. **1** and **2**, the fiber optic receptacle assembly **24** generally includes a receptacle housing **36** that defines a receptacle enclosure (not numbered in FIGS. **1** and **2**) configured to receive the plug body **26** of the fiber optic plug assembly **22**. A mating component within the receptacle enclosure communicates with the plug ferrule element **28** to establish an optical connection between the two assemblies. Additional details relating to the optical connection will eventually be described for the particular embodiment shown, but it should be noted that the description is merely provided for illustrative purposes. Optical signals may be transmitted between the plug ferrule element **28** and a mating component in ways other than described below. Indeed, the fiber optic receptacle assembly **24** may be any type of mating connector or adapter configured to cooperate with the plug body **26** of the fiber optic plug assembly **22**. The fiber optic receptacle assembly **24** may be provided in a cabinet, rack, or other device of a data center, for example.

Now referring to FIG. **3** in further detail, the plug body **26** of the fiber optic plug assembly **22** includes a main portion **40** and at least one latching arm **42** extending from the main portion **40**. First and second latching arms **42**A, **42**B on opposite sides of the main portion **40** are provided in the embodiment shown. More or fewer latching arms may be

provided in alternative embodiments (e.g., an embodiment with a single latching arm will be discussed below in connection with FIGS. **9** and **10**). More specifically, the main portion **40** includes a front end **44** and back end **46**. The front end **44** defines an insertion surface **48** and plug body opening **50** at the insertion surface. A ferrule enclosure **52** defined by the plug body **26** is in communication with or otherwise coupled in free space to the plug body opening **50**. The plug ferrule element **28** is disposed in the ferrule enclosure **52** when the fiber optic plug assembly **22** is assembled (see FIG. **1**). The back end **46** of the main portion **40** of the plug body **26** may also include an opening (not numbered) to which the ferrule enclosure **52** is coupled. Accordingly, the ferrule enclosure **52** may form a passage through the main portion **40** of the plug body **26**.

In the illustrated embodiment, an outer surface of the plug body **26** (e.g., a top surface **56** of the main portion **40**) includes an opening **58** providing access to the plug ferrule element **28** when the plug ferrule element **28** is disposed in the ferrule enclosure **52**. In some embodiments, an adhesive may be applied into the opening **58** to secure the plug ferrule element **28** to the plug body **26**. In other embodiments, no such opening **58** is provided.

The latching arms **42** each have a proximal end **60** attached to the main portion **40** of the plug body **26** and a distal end **62** offset (i.e., spaced) from the main portion **40**. Although the proximal ends **60** are shown as being attached proximate the insertion surface **48**, in alternative embodiments the latching arms **42** may be attached elsewhere to the main portion **40** of the plug body **26**. The latching arms **42** each include a projecting portion (not numbered) extending in a direction generally perpendicular to an outer surface of the main portion **40** and/or parallel to the plane of the insertion surface **48**. A latching portion (not numbered) extends in a rearward direction from the projecting portion and ultimately defines the distal ends **62** of the latching arms **42**. The overall configuration is such that the latching arms **42** are compliant in a direction transverse to the insertion direction A (FIG. **1**). Release tabs **68** may be provided on the latching arms **42**. Applying force the release tabs **68** or inserting the fiber optic plug assembly **22** into a suitable receptacle (such as the receptacle housing **36**) results in the latching arms **42** moving toward the main portion **40** of the plug body **26**. The latching arms **42** may also include a locking mechanism, such as a detent **70**, between the proximal and distal ends **60**, **62** for reasons that will be apparent based on the description below.

As mentioned above, the plug body **26** houses the plug ferrule element **28** within the plug ferrule enclosure **52**. In the illustrated embodiment, the plug ferrule element **28** has a front face **74** that defines one or more mechanical coupling surfaces and an optical interface surface (neither surface is numbered in the figures). The optical interface surface may or may not be flush with the mechanical coupling surface(s). An alignment feature, such an alignment pin **76** or alignment bore **78**, may be provided on some or all of the mechanical coupling surface(s). The alignment feature(s) are configured to engage corresponding features on the component to which the plug ferrule element **28** mates when the fiber optic plug assembly **22** is inserted into the fiber optic receptacle assembly **24**. However, any suitable alignment features are possible for mating complementary ferrule elements.

To establish an optical connection, the optical interface surface may comprise a plurality of lens elements **80** configured to be optically coupled to a plurality of optical fibers (not shown). The optical fibers are received and aligned by the plug ferrule element **28** when a fiber optic cable is connected to the fiber optic plug assembly **22**. Such an arrangement is described in U.S. Provisional Patent Application No. 61/731,581 ("the '581 application"). This type of connection, however, is merely an example. Persons skilled in the art will appreciate that features pertaining to other components of the fiber optic plug assembly **22** (e.g., the plug body **26** and cable attachment element **30**) may be used in connection with plug ferrule elements having different designs. For example, the plug ferrule element **28** may be designed to optically couple the fiber optic plug assembly **22** to a mating component without the use of lens elements. Even further, the concepts disclosed for the fiber optic plug assembly **22** may be designed to couple to a mating component without using any ferrule element.

Now referring to FIGS. **3** and **4**, the cable attachment element **30** includes a front portion **82** configured to engage the plug body **26**, a rear portion **84** from which the front portion **82** extends, and a passage **86** configured to allow one or more optical fibers from a fiber optic cable to extend through the cable attachment element **30**. The front portion **82** is defined by first and second attachment prongs **88**, **90** in the illustrated embodiment, with each attachment prong including at least one latching element **92** (shown as a detent). The rear portion **84** includes one or more flanges or yokes **96** extending in a generally radial direction (i.e., generally transverse to the axis of the passage **86**). One or more receiving areas **98** may be provided in the rear portion **84** for reasons that will be discussed below. The cable attachment element **30** may also include an extending or ridged portion **100** that extends in a rearward direction from the rear portion **84**. The extending portion **100** is configured to engage the strain relief element **32**.

FIG. **5** illustrates the fiber optic plug assembly **22** in an assembled state but disconnected from the fiber optic receptacle assembly **24** (also shown in an assembled state in FIG. **5**). FIG. **6** is similar but illustrates the fiber optic plug assembly **22** and fiber optic receptacle assembly **24** connected together. The figures are illustrated in cross-section so that the components of the assemblies and can be seen in further detail.

As shown in FIGS. **5** and **6**, the plug ferrule element **28** is disposed in the ferrule enclosure **52** of the plug body **26** such that the front face **74** of the plug ferrule element **28** is offset (e.g., recessed rearward) from the insertion surface **48** of the plug body **22**. Having the plug ferrule element **28** recessed within the plug body **26** protects the lens elements **80** of the plug ferrule element **28** from mechanical damage or inadvertent contamination but still allows cleaning. The plug ferrule element **28** may be retained in the ferrule enclosure **52** by providing appropriate features (e.g., ridges) on interior walls of the plug body **26**. The plug ferrule element **28** may also be configured to float (i.e., move slightly in a direction transverse to insertion direction A) within the ferrule enclosure **52** to aid in finely aligning the plug ferrule element **28** during connection to a mating component. These and other aspects are described in further detail in the '581 application mentioned above. Again, however, the embodiment shown is merely an example and other plug ferrule element designs and interactions with a plug body will be appreciated by persons skilled in the art.

It is noted that a bias member (e.g., one or more springs) is not provided within the ferrule enclosure **52** in the illustrated embodiment. As described below, a bias member **110** is provided in the fiber optic receptacle assembly **24**. The bias member **110** maintains the plug ferrule element **28** and a receptacle ferrule element **112** in an optically-coupled relationship when the two ferrule elements are mated together. In

alternative embodiments, however, one or more bias members may be provided in the plug body **26** as desired.

At least one of the interior walls of the plug body **26** includes an attachment element **114** configured to engage a corresponding latching element **92** on the front portion **82** of the cable attachment element **30**. In the embodiment shown, opposite interior walls of the plug body **26** include attachment elements **114** in the form of openings or windows. As mentioned above, the first and second attachment prongs **88**, **90** of the cable attachment element **30** include respective latching elements **92** in the form of detents. When the first and second attachment prongs **88**, **90** are inserted in the back end **46** of the plug body **26**, the detents **92** engage the openings **114** to secure the cable attachment element **30** to the plug body **26**. The openings **144** need not completely extend through the interior walls of the plug body **24** in alternative embodiments.

Inserting the front portion **82** of the cable attachment element **30** in the back end **46** of the plug body **26** also brings the rear portion **84** of the cable attachment element **30** into a position that shields/captivates the latching arms **42** of the plug body **26**. More specifically, and with reference to FIGS. **7** and **8**, the rear portion **84** remains located outside of the main portion **40** of the plug body **26**. The flanges **96** on the rear portion **84** receive at least a portion of the latching arms **42**. The manner in which this occurs may vary, but generally the arrangement is such that a portion of each flange **96** is located on a side of the latching arm **42** opposite the main portion **40** of the plug body **26**. For example, a portion of each flange **96** may be offset from the main portion **40** of the plug body **26** (and/or insertion direction A) by a greater extent than the portion of the latching arm **42** being received. This portion of each flange **96** may extend over, around, or otherwise next to the latching arm **42** when the latching arm **42** is received. The arrangement may be such that the outward over-extension or movement of the latching **42** away from the main portion **40** of the plug body is in some way confined, restricted, or limited.

In the embodiment shown, a receiving zone **98** is provided in each flange **96** for receiving the distal ends **62** of the latching arms **42**. The receiving zones **98** are shown in the form of pockets or openings that completely surround the distal ends **62** of the latching arms **42**, although embodiments where pockets or openings only partially surround the distal ends **62** are also possible. The receiving zones **98** may have any shape so long as they accommodate the distal ends **62** of the latching arms **42**. The receiving zones **98** are also shaped such that the latching arms **42** remain compliant in a direction transverse to the insertion direction A (FIGS. **1** and **5**). In other words, there is sufficient space to move the distal ends **62** in the receiving zones **98** toward and/or away from the main portion **40** of the plug body **26**. The distal ends **62** of the latching arms **42** may extend through the receiving zones **98** and slightly beyond the flanges **96** or may terminate within the receiving zones **98**. Accordingly, in alternative embodiments the receiving zones **98** may be openings or pockets with a bottom surface (e.g., cups or recesses) such that the receiving zones **98** do not extend through the flanges **96**.

It will also be appreciated that the rear portion **84** of the cable attachment element **30** may shield or protect the latching arms **42** without the use of pockets or openings. For example, in alternative embodiments the flanges **96** may simply confront (and possibly abut) the distal ends **62** of the latching arms **42**. FIG. **8**A is a schematic illustration of this type of arrangement. Even if the latching arms **42** are shorter in such embodiments, a terminal portion **116** of each flange **96** may extend forward, generally parallel to the insertion direction A (FIGS. **1** and **5**) such that the flanges **96** would still receive the distal ends **62** of the latching arms **42**. The terminal portions **116** may serve as receiving zones that prevent the distal ends **62** from moving outwardly (i.e., away from the main portion **40** of the plug body **26**) beyond a certain extent. Terminal portions **116** are also shown in the embodiment of FIGS. **7** and **8** to illustrate that different types of receiving zones may be provided in the same embodiment (e.g., pockets **98** and terminal portions **116**).

The latching arms **42** may be configured such that no movement toward the main portion **40** of the plug body **26** is required in order to be received by the rear portion **84** of the cable attachment element **30**. In other words, it may not be necessary to squeeze or push the latching arms **42** inwards while inserting the cable attachment element **30** into the back end **46** of the plug body **26** so that a portion of each latching arm **42** (e.g., the distal end **62**) can be located between the main portion **40** of the plug body **26** and the portion of the cable attachment element **30** that receives the latching arm **42** (e.g., the receiving zones **98** and/or terminal portion **116**). Some clearance or space may remain between the cable attachment element **30** and latching arm **42** that not only allows inward movement toward the main portion **40** of the plug body **26** (as discussed above in connection with the receiving zones **98**), but also outward movement. Eventually, however, contact with the portion of the cable attachment element **30** that receives the latching arm **42** restricts or delimits movement of the latching arm **42** away from the main portion **40** of the plug body **26**.

In alternative embodiments, the latching arms **42** may be configured such that inward movement is required. In other words, it may be necessary to squeeze or push the latching arms **42** inwards while inserting the cable attachment element **30** into the back end **46** of the plug body **26** so that a portion of each latching arm **42** (e.g., the distal end **62**) can be located between the main portion **40** of the plug body **26** and the portion of the cable attachment element **30** that receives the latching arm **42** (e.g., the receiving zones **98** and/or terminal portion **116**). This may be accomplished by applying force to the release tabs **68**, for example. The force may be released once the latching arms **42** are received by the cable attachment element **30**. If the latching arms **42** are resilient, they then may move back outward until contact is made with the cable attachment element **30**. Any internal spring force/resiliency remaining may help maintain this contact.

Persons skilled in the art will appreciate various additional features for the above-described embodiments. For example, regardless of whether the latching arms **42** must be moved inward during insertion of the cable attachment element **30** into the back end **46** of the plug body **26**, the rear portion **84** of the cable attachment element **30** may include a ramp or some other lead-in feature (not shown) to help guide the latching arms **42** into a position where the rear portion **84** can receive the latching arms **42**. Even in embodiments not requiring inward movement of the latching arms **42** under normal circumstances, such a lead-in feature may still be advantages in case the latching arms **42** are somehow pushed slightly outward or deformed (thereby representing a deviation from normal circumstances).

FIGS. **7** and **8** also illustrate how the first latching arm **42**A may include a keying feature **118**. The keying feature **118** helps ensure proper alignment when the fiber optic plug assembly **22** is inserted into the fiber optic receptacle assembly **24**, which may include a corresponding keying feature (not shown) for this purpose. Keying features for other purposes (e.g., security) may also be provided on the latching arms **42** or elsewhere on the plug body **26**.

Referring back to FIGS. **5** and **6**, the configuration of the plug body **26** is such that it mates with the receptacle housing **36** of the fiber optic receptacle assembly **24**. The plug body **26** is inserted into the receptacle housing **36** through a receptacle opening **120**. The detents **70** of the latching arms **42** may be ramped to facilitate the latching arms **42** deflecting inwards when the detents **70** contact walls of the receptacle housing **36** that define edges of the receptacle opening **120**. This allows the plug body **26** to be inserted further into the receptacle housing **36**. Eventually the detents **70** engage corresponding locking mechanisms on the receptacle housing **36**. In the embodiment shown, the locking mechanisms are lock openings or windows **122** in opposed walls of the receptacle housing **36**. The lock openings **122** are large enough to accommodate the detents **70** such that the latching arms **42** of the plug body **26** can move away from the main portion **40** of the plug body **26**, back toward a non-deflected position. This brings rear surfaces of the detents **70** into a position that helps prevent withdrawal of the plug body **26** from the receptacle housing **36**. Specifically, the detents **70** are shaped to engage the lock openings **122** upon attempted withdrawal. Thus, the engagement between the detents **70** and lock openings **122** helps secure the fiber optic plug assembly **22** to the fiber optic receptacle assembly **24**.

It should be noted that the fiber optic receptacle assembly **24** is shown as further comprising a receptacle the bias member **110** and receptacle ferrule element **112** mentioned above, along with a clip member **124**. The receptacle ferrule element **112** is disposed within a receptacle enclosure **126** defined by the receptacle housing **36** and is the mating component to which the plug ferrule element **28** is optically coupled when the fiber optic plug assembly **22** is secured to the fiber optic receptacle assembly **24**. To this end, and consistent with the statements above, the receptacle ferrule element **112** is only shown for illustrative purposes and will not be described in detail. Reference can be made to the '581 application (mentioned above) for a better understanding of such an embodiment. The same applies to a description of the bias member **110** and clip member **124**.

To remove the fiber optic plug assembly **22** from the fiber optic receptacle assembly **24**, a user may apply force to the release tabs **68** of the latching arms **42** to move the detents **70** away from the lock openings **122**. Such movement is permitted despite the distal ends **62** of the latching arms **42** being positioned within the receiving zones **98**, as mentioned above. The fiber optic plug assembly **22** may then be pulled out of the fiber optic receptacle assembly **24**.

During withdrawal or general handling of the fiber optic plug assembly **22**, the latching arms **42** remain positioned within the receiving zones **98**. The receiving zones **98** surrounding the distal ends **62** help prevent the latching arms **42** from catching or snagging other components/structures in the surrounding environment (not illustrated in the figures). To this end, the chances of the latching arms **42** being bent, twisted, or otherwise deformed, or even broken in part or snapped off from the main portion **40** of the plug body **26**, are reduced or eliminated. Thus, a safer and more robust design is provided by shielding/protecting the latching arms **42** in this manner.

Advantageously, the robust design inhibits damage and is achieved without significantly increasing the complexity of the optical connector system **20**. The shielding of the latching arms **42** is integrated into the rear portion **84** of the cable attachment element **30**. No additional components are necessary. Nor are any modifications to the fiber optic receptacle assembly **24** or other component to which the fiber optic plug assembly **22** is intended to mate necessary. Furthermore, the rear portion **84** of the cable attachment element **30** may be designed to not project outwardly (i.e., generally transverse to insertion direction A) further than the outermost portions of the latching arms **42** (the release tabs **68** in the embodiment shown). The overall profile of the fiber optic plug assembly **22** may therefore be maintained despite incorporating the shielding/captivating features described above. Thus, an esthetic and ergonomic design may still be provided. This is particularly advantageous for fiber optic plug assemblies designed for high fiber counts in that the plug ferrule elements and plug bodies for such assemblies may already be relatively wide to accommodate a large number of optical fibers.

FIGS. **9** and **10** illustrate an optical connector system **150** according to an alternative embodiment in disconnected and connected states, respectively. The optical connector system **150** is similar to optical connector system **20** in most respects, and the same reference numbers are used in the figures to refer to corresponding elements. In the optical connector system **150**, only a single latching arm **42** is provided on the plug body **26** of the fiber optic plug assembly **22**. The rear portion **84** of the cable attachment element **30** may therefore include only a single flange **96** and receiving zone **98**, if desired. Additionally, a corresponding modification may be made to the fiber optic receptacle assembly **24**, i.e. the receptacle housing **36** may only have a single lock opening **122** for cooperating with the detent **70** on the latching arm **42** of the plug body **26**. The latching arm **42** operates in the same manner as in the previously discussed embodiment, with the rear portion **84** shielding/captivating the distal end **62** of the latching arm **42** to help prevent catching or snagging. Thus, the advantages described above remain equally applicable. Providing a single latching arm **42** has the additional advantage of being able to serve as a keying feature for alignment and/or security. In particular, the receptacle housing **36** may have a receptacle opening **152** with a groove or cutout **154** in a wall extending from the receptacle opening **152**. The groove or cutout **154** has a shape corresponding to the latching arm **42** so that the plug body **26** of the fiber optic plug assembly **22** may only be inserted into the receptacle housing **36** with the proper orientation (i.e., the latching arm **42** being aligned with the groove or cutout **154** in the receptacle housing **36**).

Another modification embodied by the optical connector system **150** is that the main portion **40** of the plug body **26** does not include an opening on an outer surface to provide access to the plug ferrule element **28**.

Many additional modifications, regardless of whether such modifications relate to the safety features mentioned above, will be readily apparent to persons of ordinary skill in the art to which this disclosure relates. Thus, persons of ordinary skill in the art will appreciate additional embodiments and examples when having the benefit of the teachings presented in the above description and the associated drawings. These additional embodiments and examples are intended to be covered by the present disclosure provided that they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A fiber optic plug assembly for a fiber optic cable having at least one optical fiber, the fiber optic plug assembly comprising:

a plug body having a main portion and at least one latching arm extending from the main portion, wherein the at least one latching arm comprises a proximal end attached to the main portion and a distal end offset from the main portion, and wherein the main portion has a front end and back end; and

a cable attachment element having a front portion received in the back end of the main portion of the plug body, a

rear portion located outside of the plug body, and a passage configured to allow the at least one optical fiber to extend through the cable attachment element and into the main portion of the plug body, wherein the rear portion of the cable attachment element receives at least a portion of the at least one latching arm and comprises a receiving zone that at least partially surrounds the distal end of the at least one latching arm, and wherein the receiving zone comprises an opening in which the distal end of the at least one latching arm is positioned.

2. The fiber optic plug assembly of claim **1**, wherein the opening of the receiving zone extends through the rear portion of the cable attachment element, and further wherein the distal end of the at least one latching arm extends partially or completely through the opening of the receiving zone.

3. The fiber optic plug assembly of claim **1**, wherein the at least one latching arm is positioned parallel to an insertion direction of the fiber optic plug assembly.

4. The fiber optic plug assembly of claim **3**, wherein the at least one latching arm is compliant in a direction transverse to the insertion direction.

5. The fiber optic plug assembly of claim **1**, wherein the at least one latching arm comprises a detent.

6. The fiber optic plug assembly of claim **1**, wherein the at least one latching arm comprises a keying feature.

7. The fiber optic plug assembly of claim **1**, wherein first and second latching arms are positioned on opposite sides of the main portion of the plug body.

8. The fiber optic plug assembly of claim **1**, wherein the plug body further defines a plug body opening at the front end of the main portion and a ferrule enclosure coupled in free space to the plug body opening, the fiber optic plug assembly further comprising:

a plug ferrule element disposed within the ferrule enclosure of the plug body and accessible through the plug body opening.

9. The fiber optic plug assembly of claim **8**, wherein the cable attachment element is coupled to the plug body at a rear opening of the plug body that is opposite from the plug body opening, and further wherein the ferrule enclosure is coupled in free space to the rear opening such that the front portion of the cable attachment element extends into the ferrule enclosure.

10. The fiber optic plug assembly of claim **1**, further comprising a strain relief element disposed about the cable attachment element.

11. The fiber optic plug assembly of claim **10**, wherein the cable attachment element further comprises a ridged portion extending rearwardly from the rear portion for engaging the strain relief element.

12. The fiber optic plug assembly of claim **1**, wherein the front portion of the cable attachment element comprises at least one latching element configured to engage an attachment element on the main portion of the plug body.

13. The fiber optic plug assembly of claim **12**, wherein the at least one latching element on the front portion of the cable attachment element comprises at least one attachment prong.

14. An optical connector system, comprising:

a fiber optic plug assembly for a fiber optic cable having at least one optical fiber, the fiber optic plug assembly comprising:

a plug body having a main portion and at least one latching arm extending from the main portion, wherein the main portion has a front end and back end, and wherein the plug body further defines a plug body opening at a front end of the main portion and a ferrule enclosure coupled in free space to the plug body opening;

a plug ferrule element disposed within the ferrule enclosure of the plug body and accessible through the plug body opening; and

a cable attachment element having a front portion received in the back end of the main portion of the plug body, a rear portion located outside of the plug body, and a passage configured to allow the at least one optical fiber to extend through the cable attachment element and into the main portion of the plug body, wherein the rear portion of the cable attachment element receives at least a portion of the at least one latching arm; and

a fiber optic receptacle assembly comprising a receptacle housing that defines a receptacle enclosure configured to receive the plug body of the fiber optic plug assembly, wherein the receptacle housing includes at least one locking mechanism configured to engage the at least one latching arm of the plug body when the plug body is inserted into the receptacle enclosure.

15. The optical connector system of claim **14**, wherein the at least one latching arm of the plug body comprises a detent and the at least one locking mechanism of the receptacle housing comprises at least one lock opening configured to cooperate with the detent.

16. The optical connector system of claim **14**, wherein the fiber optic receptacle assembly further comprises a receptacle ferrule element disposed within the receptacle enclosure and configured to mate with the plug ferrule element.

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